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(56) Documents Cited

GB 2160366 A

GB 0585912 A

EP 0216366 A2

US 4876441 A

(58) Field of Search

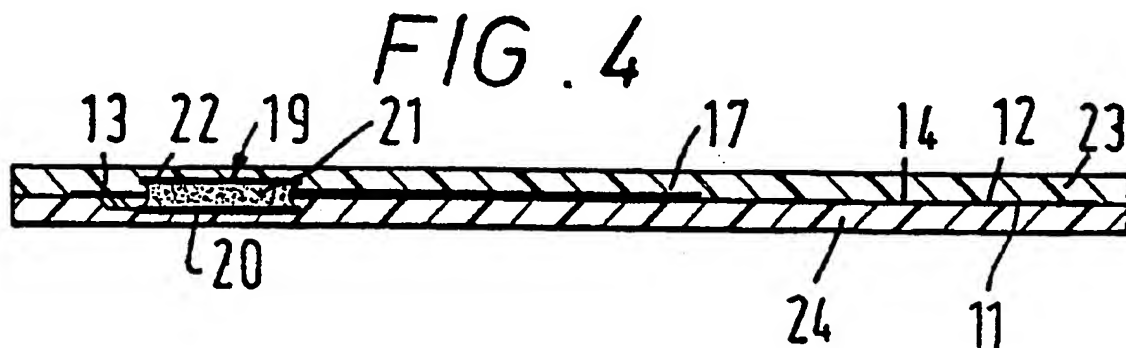
UK CL (Edition M) B6A AK, H1R RAS

INT CL⁵ G06K 19/077

(54) Flexible mountings for electronic components in smart cards.

(57) A printed circuit board is provided with a flexibly attached limb or tab on which an encapsulated electronic component or assembly is mounted, such that the encapsulated portion can assume its own orientation in a completed device incorporating the board.

As shown (Fig. 4), a smart card comprises a printed circuit board 17 sandwiched between two plastic laminae 23, 24. An encapsulated electronic sub-assembly 19 is mounted on a portion 22 of the board 17 which is only attached to the main portion of the board 17 by a flexible bridge portion (not shown) which bears the connections. Accordingly the potted components are able to adopt a centralised position between the surface laminae 23, 24.



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FIG. 1

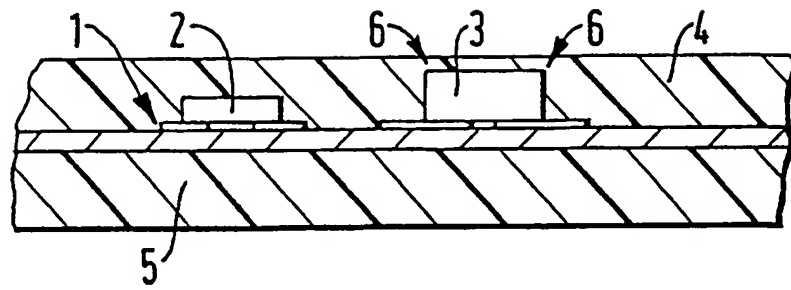


FIG. 2

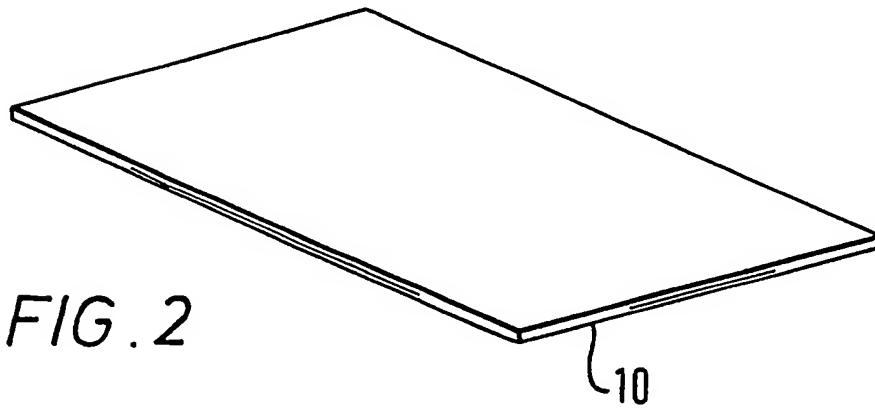


FIG. 3

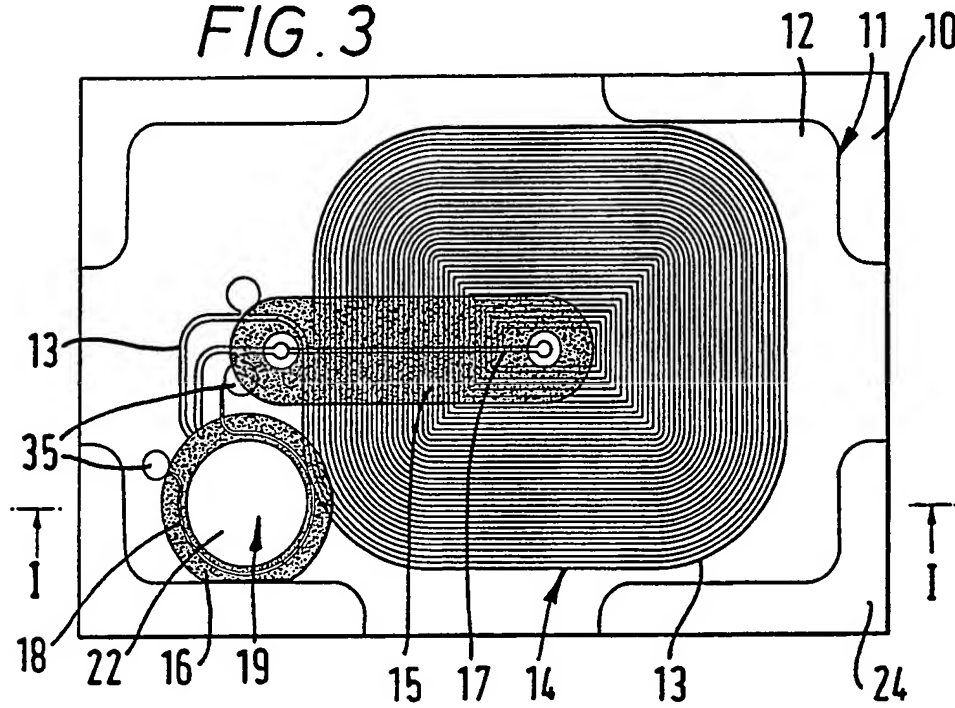


FIG. 4

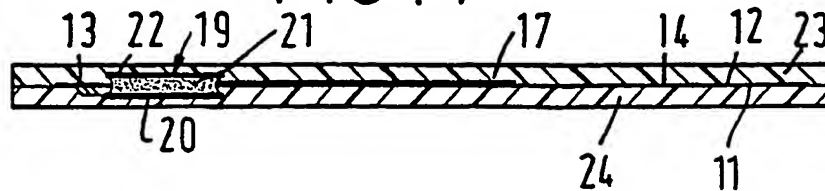


FIG. 5

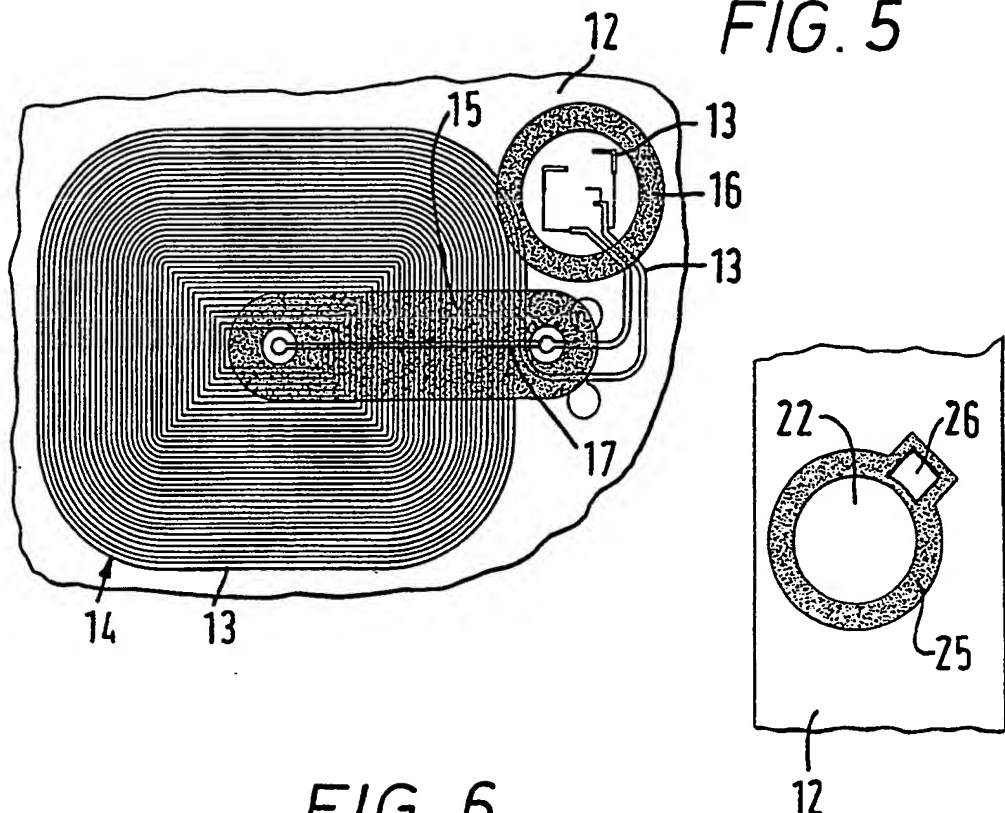


FIG. 6

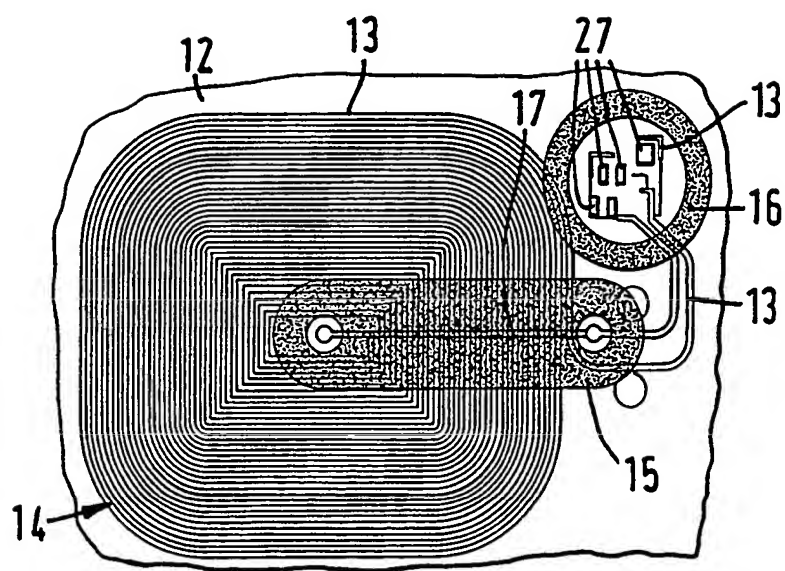


FIG. 7

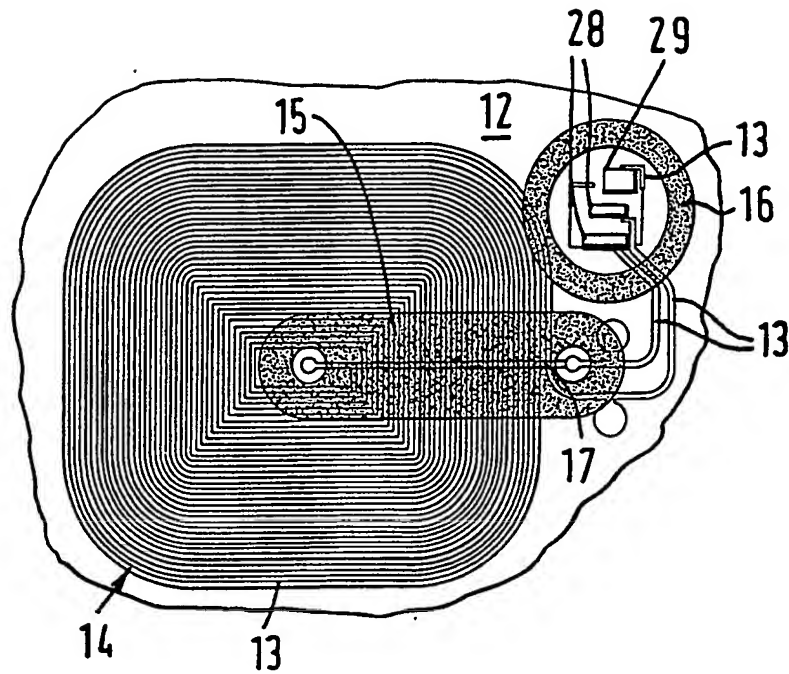


FIG. 8

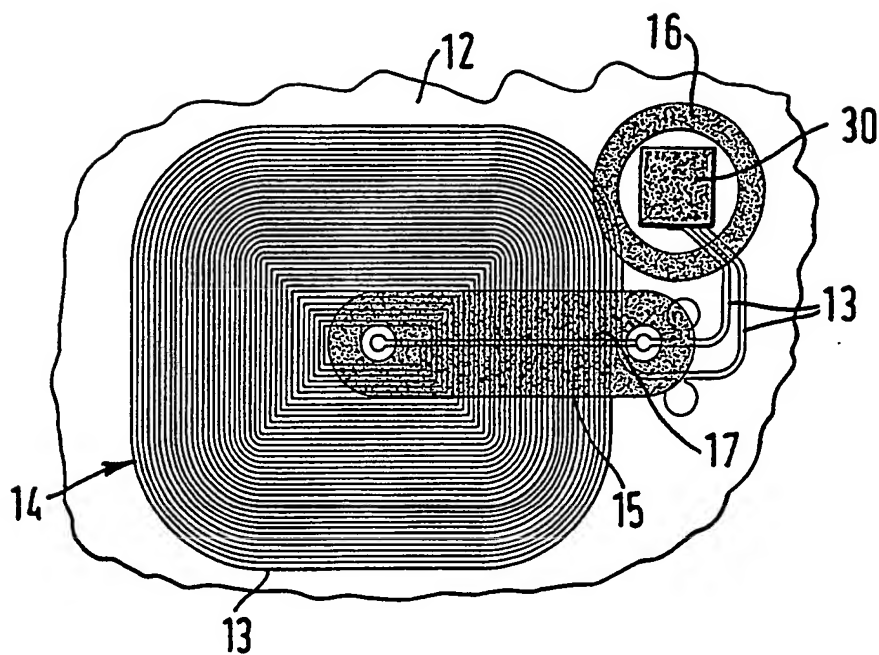


FIG. 9

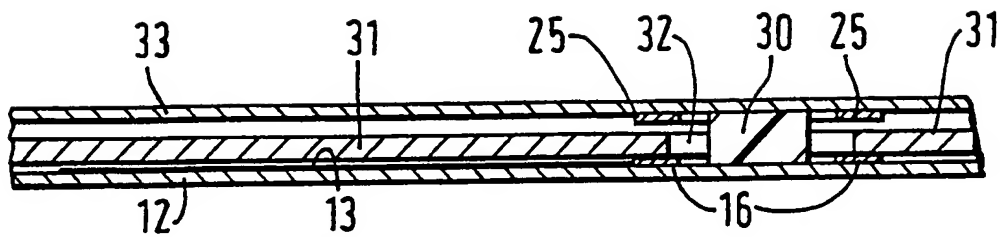


FIG. 10

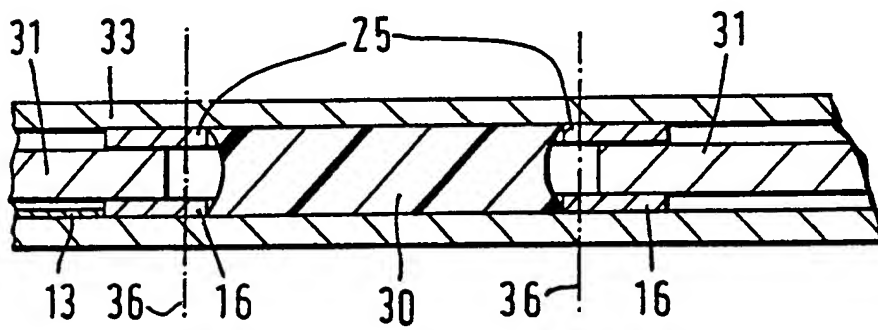
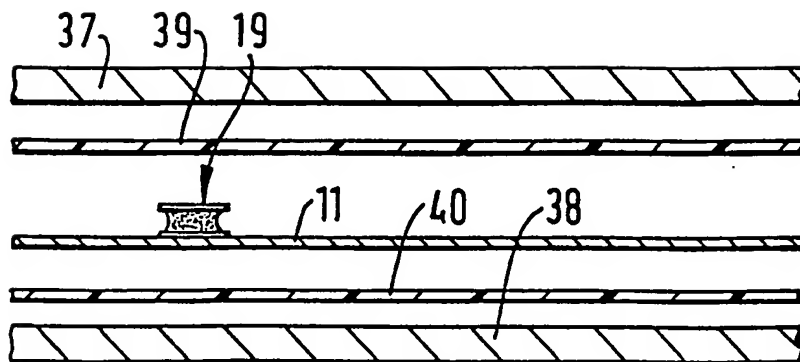


FIG. 11



AN INTEGRATED CIRCUIT CARD

This invention relates to an integrated circuit card comprising a flexible printed circuit embedded in a protective material and to a method of producing such a card.

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There is a demand for such cards having a thickness of the order of 1 mm and which are sufficiently robust so as to withstand some degree of flexing which is inevitable with such a thin card. These cards are commonly used for security purposes and as transaction cards and preferably have the same dimensions as so called "plastic cards".

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The initial proposal was to form the card in the manner depicted in Fig 1 where a flexible printed circuit 1, carrying electronic components 2 & 3 is shown laminated between two sheets of plastics material 4 & 5. (Note that the term "printed circuit" as used in this specification should be considered to refer to any system of conductive tracks on an insulating substrate, whether such tracks are formed by printing, etching, vapour deposition or any other technique.)

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The top sheet 4 needs to be thick enough to allow the largest component 3 to become embedded in it during fabrication. The bottom sheet 5 needs to be of similar thickness so as to place the circuit 1 at least approximately centrally between opposite sides of the card thereby reducing strain on the circuit when the card is flexed. Unfortunately it was found that a sufficiently thin structure could not be formed in this way. Furthermore it was found that stresses cause by flexing of the card resulted in the failure of the plastics material at position

such as point 6, this causing the larger components, such as 3 to "break out" of the structure. In an attempt to solve the above problem the present applicant previously proposed, in UK patent application GB2253591A, offsetting electronic elements relative to the plane of the printed circuit on which they are positioned by forming recesses in the printed circuit in which recesses the electrical elements are located.

The object of the present invention is to provide an improved integrated circuit card and method of producing such a card.

According to a first aspect the present invention there is provided an integrated circuit card comprising a printed circuit on a limb of which is mounted an electronic element embedded in a protective layer on the card.

By employing the present invention it is possible to make a particularly thin card, because the total thickness of the card need only marginally exceed the thickness of the thickest "electronic element" (by which term it is meant an electrical component or an electrical component or components and any associated encapsulation material). The element preferably adopts a position between sandwiching layers of protective material without influencing the position of the rest of the printed circuit, allowing for the printed circuit to be centrally positioned in the card so as to reduce stresses when the card is flexed, the element lying in the plane of the printed circuit. This latter point is particularly important because the thinness of the card will inevitably result in increased flexibility. Alternatively employing the present invention enables a part of the printed circuit to be at a known

particular position relative to the surfaces of the card whilst permitting the element to adopt its own position within the card. This is desirable if for example one portion of the printed circuit comprises electrical contacts which are to be at the surface of the card.

5 The electronic element may be an electronic component, for example a capacitor or an integrated circuit. In one preferred form of the invention the "electronic element" is a capsule formed by one or more of such electrical components embedded in a potting compound.

10 The limb may according to one embodiment of the invention be formed by a cut in the substrate material of the printed circuit and may be entirely surrounded by substrate material or may extend to an edge thereof. Alternatively the electronic element is fabricated on a first part of the printed circuit which part is subsequently connected to a second part of the printed circuit.

15 The electronic element preferably has a tapered waist and is located in an aperture in the printed circuit, the relative dimensions of the aperture and element being such that the element is retained in the aperture by the waist prior to the connection of the first part of the printed circuit to the second part. This enables the element to be retained in position whilst
20 being connected to the second part of the printed circuit. The present invention is particularly advantageous where the card includes an inductive loop for communication between components of the electronic element and electronic circuitry external to the card.

It is particularly advantageous if the card is rectangular and the electronic element is located in one corner of the card with the limb extending to the element across a major axis of the card in the region where it meets the edge of the electronic element. Because the card is less prone to flexure along a major axis than along a shorter axis the point at which the flexible printed circuit joins the relatively hard electronic element is subjected to less stress which could lead to failure.

According to a second aspect of the present invention there is provided an electronic element comprising one or more electronic components encapsulated on a printed circuit which printed circuit has a limb portion extending from the encapsulated portion for connecting to a second part of a printed circuit of a integrated circuit card.

According to a third aspect of the present invention there is provided a method of producing an integrated circuit card comprising assembling electrical components on a limb of a printed circuit, encapsulating the components to form an electronic element and sandwiching the printed circuit and electronic element between two sheets of plastics material such that the printed circuit and electronic element become embedded in the plastics material, wherein the limb permits the electronic element to adopt its own position relative to a plane on which the printed circuit lies.

One embodiment of the invention will now be described, by way of example only, with reference to Figures 2 to 11 of the accompanying drawings in which like numerals have been used to indicate like parts, and of which:

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Figure 1 schematically illustrates a previously proposed arrangement (not in accordance with the invention) of electrical components in a plastic card;

5 Figure 2 is a perspective view of a plastic card in accordance with the present invention;

Figure 3 is a plan view of the card of Figure 2 having its top sheet 4 removed to reveal the printed circuit;

10 Figure 4 is a cross-section through the card along the line I - I of Figure 3; and

Figures 5 to 11 illustrate various stages in the production of the plastic card depicted in Figures 2 to 4.

15 Referring first to Figure 2 there is shown a perspective view of the final card which has the same external dimensions as a standard "plastic card". The card contains an integrated circuit. On Figure 2 it is possible to see edge portions of a substrate of the integrated circuit, exposed at a central part of each edge of the card. The integrated circuit communicates with interrogation units via an inductive link located at appropriate locations.

20 The integrated circuit would normally contain a memory device and could be used for any number of purposes, for example recording banking transactions or recording zones of buildings etc to which entry has been gained by use of the card as an identity card.

Referring to Figure 3 there is illustrated a plan view through a section of the card 10 of Figure 2 in the plane of the card. From this and the cross-section along line I - I illustrated in Figure 4 it can be seen that a printed circuit 11 comprises epoxy/glass substrate 12 and conductive tracks 13, a substantial portion of which form conductive loop 14. Darkly shaded regions 15 and 16 comprise of a thermoset dielectric material. The purpose of the region 15 is to insulate a silver conductor 17 from the inductive coil 14. The purpose of dielectric layer 16 will be explained later.

An integrated circuit and capacitive components, not shown in Figures 3 or 4, are contained within a capsule-like element 19 which is separated by cut 18 from the rest of the substrate 12. The region 20 of the substrate 12 is lowered below the plane of the printed circuit 11, the integrated circuit and capacitive components being located in potting compound 21 sandwiched between the portion of the substrate 20 and a capping portion 22 of the same material as the substrate 12.

The printed circuit 11 and element 19 are sandwiched between two outer sheets 23 and 24 of PVC thermoplastics material and two intervening layers (not shown in Figures 3 or 4), of polyester which is coated on both sides with a thermally activated catalyst adhesive by which the laminated structure is adhered. This polyester acts as a reinforcing layer preventing element 19 "breaking out" of the PVC layers 23 and 24.

The fabrication process of the card illustrated in Figures 2, 3 and 4 begins with a substrate sheet 12 of copper-clad epoxy/glass which is etched to form a large number of

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identical printed circuits 13, each as illustrated in Figure 5. On top of each printed circuit is printed a thermoset dielectric material indicated by the shaded regions 15, 16 which is cured in place. The function of circular part 15 is explained below. The linear part 16 serves as an insulator to separate printed conductive link 17 between inner and outer ends of a coil 14 defined by part of the printed circuit 13. Separated from a main part of the substrate by lines of weakness not shown are a number of strips (not shown), each carrying printed patterns 25 (only one of which is illustrated), with apertures 26 therein, which ultimately become the top reinforcing caps of the elements 19.

The substrate carrying the etched patterns is placed on a bed of a screen printing machine (not shown) and a screen placed over it. A squeegee is then used to print a low ionic epoxy encapsulant/adhesive material onto positions 27 as shown in Figure 6. This is a mixture of a resin and a catalyst which sets hard when cured. Suitable materials are, for example, available from Ablestick, Encaremix, or Dexter Hisol. The substrate is then placed in a "pick-and-place" machine which places components comprising of capacitors 28 and silicon chips 29, shown in Figure 7, onto the epoxy which acts as an adhesive to hold them in place. The silicon chips 29 at this stage are "naked", that is to say they are not encapsulated. A notable feature of this process is that the epoxy is applied to areas where there is no copper layer, this being unnecessary because of the adhesive attachment of the components. A saving of 35 microns in thickness is thus achieved as compared with arrangements where components are soldered on top of a copper track. It will be appreciated that this reduction of thickness may be of crucial importance in situations where there may typically be a requirement for the entire assembly not to exceed 760 microns. An advantage

of using epoxy adhesive is that if suitably selected it remains in its adhesive state for a sufficient time period which exceeds the maximum period during which the screen printing machine is not being operated. This avoids the need to clean down the equipment.

5 The sheet substrate carrying the etched patterns and respective components positioned on it, is then baked until the epoxy has gelled, i.e. set but not hardened. This takes place under a flow of nitrogen to prevent oxidation of the copper. The sheet is then placed on the work-holder of a wire bonding machine where it is held in position by a vacuum. Suitable machines for this purpose are commercially available. Wire connections are then made
10 between contacts on the individual components to appropriate parts of the printed copper circuitry. This is done by an ultrasonically assisted diffusion welding process. The sheet is then placed back in the screen printer with a different stencil in place. This stencil is much thicker, its thickness being selected so that the same epoxy encapsulant/adhesive now to be deposited over the components is sufficient to cover them completely. Notably, this material
15 is the same as that which was used for the adhesive. It does not have to be the same but it preferably has similar physical characteristics. After the removal of the stencil, the sheet is as shown in Figure 8, the components being encapsulated by the encapsulant 30.

Figure 9 shows in cross-section the next stage of the process where a copper spacer
20 31 having a plurality of apertures 32 (corresponding to each of the regions on the sheet having encapsulant 30 deposited thereon) is located on the sheet, 12. Previously placed on the copper sheet is each of the now separated strips 33, previously referred to, to form regions defined by printed patterns 25, from which regions reinforcing caps 22 will be formed. The

spacer 31, with strips 33 located on it by means of pins (not shown for clarity), has been placed on top of the substrate. The whole arrangement is then pressed such that the patterns 25 are pressed into contact with the spacer 31 which is thus pressed closely down onto the circular part 16 of the dielectric material. It also presses the portions of the strip 33 defined by the patterns 25 onto the, still soft, epoxy encapsulant/adhesive thereby pulling the entire assembly down to the desired height. During this process the encapsulant spreads out as shown in detail in Figure 10, but not as far as the edges of the spacer sheet. It is prevented from doing so by its meniscus acting against the inner edges of the copper pattern 25 and dielectric ring 16, which meniscus thereby defines the radius of the encapsulant.

The whole assembly is now placed in an oven and cured at a temperature of 150°C. This fully gels the encapsulant/adhesive both under the components and the encapsulant portion. The assembly is now placed on a rule die which forms cuts 34 which can be seen in Figure 3. These cuts are "horseshoe-shaped" and configured so that their free ends correspond with the slots 26 (see Figure 5) in the strip 33. Note at this stage that the ends of each cut are located on the copper pads 35 of Figure 3. The cutter presses through the structure as illustrated by dotted lines 36 in Figure 10, leaving the element 19 on a limb of the substrate 11, as is best seen from Figure 3, and leaving the spacer 31 and remaining portions of the strips 33 free to be removed.

It will be noted from Figure 3 that the electrical connections to the element run parallel to an edge of the card, in which direction the card is most resistant to bending, as opposed to across the hinge line which runs across the corner of the card where it is most

susceptible to bending.

Using another rule die, cruciform shapes are cut out of the assembly to give each printed circuit the shape illustrated in Figure 3. This removes the epoxy/glass substrate from these areas which are to become the corners of the finished cards. It is notably these corner parts which are most subject to the type of manipulation which encourages de-lamination.

The printed circuit 1 with reinforced element 19 is now placed, as shown in Figure 11, between two outer sheets 37 and 38 of thermo plastics material in the pvc family with the inter-position of polyester layers coated on both sides with a thermally activated catalyst adhesive 21. The assembled sandwich is placed in a press where it is heated to cause lamination. During this stage the capsules 18 imbed themselves in each of the sheets of thermo-plastic material in such a way as to tend to centralise themselves between opposite faces leaving the plane of the substrate sheet 1 on the central axis as shown in Figure 4. The press now opens and the assembly is removed to a cutting machine where the individual cards as illustrated in Figures 2 and 3 are cut out.

Although in the specific embodiment illustrated each electronic element is formed integrally with the printed circuit, each element could alternatively be formed on a separate part of the printed circuit which is subsequently connected to the main part of the printed circuit, the element being retained in an aperture in the main printed circuit formed by a circular or similar cutter by being "snapped" into the aperture, the end faces of the element being of slightly greater diameter than the aperture. The elements would be formed by a

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process very similar to that disclosed except they would be formed on a substrate having a far greater density of elements, from which substrate they would eventually be cut. The elements can be cut from the substrate having a limb extending from the element by which they are connected to the main portion of the printed circuit of a card by normal soldering
5 of conductive tracks on the limb to tracks on the printed circuit or by similar techniques.

The card shown in the illustration shows an electronic element connected to an inductive loop 14 in a contactless card. The electronic element could alternatively be connected by means of a limb to an electrical contact or other component of a card.

CLAIMS

1. An integrated circuit card comprising a printed circuit on a limb of which is mounted an electronic element embedded in a protective layer on the card.

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2. A card as claimed in claim 1 wherein the element comprises one or more electrical components embedded in a potting compound.

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3. A card as claimed in claim 1 or claim 2 wherein the element is located in a position adapted during fabrication of the card by the action of being sandwiched between two sheets of plastics material of the card.

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4. A card as claimed in claim 1, 2 or 3 wherein the element lies in the plane of the printed circuit.

20

5. A card as claimed in any preceding claim wherein the limb is formed by a cut in the substrate material of the printed circuit.

6. A card as claimed in any one of claims 1 to 4 wherein the electronic element is fabricated on a first part of the printed circuit which part is subsequently connected to a second part of the printed circuit.

7. A card as claimed in claim 6 wherein the electronic element has a tapered waist and

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is located in an aperture in the printed circuit, the relative dimensions of the aperture and element being such that the element is retained in the aperture by the waist prior to the connection of the first part of the printed circuit to the second part.

- 5 8. A card as claimed in any preceding claim wherein the element is located such that it is intersected by a plane on which the printed circuit lies.
9. A card as claimed in any preceding claim wherein the printed circuit includes an inductive loop for communication between components of the electronic element and
- 10 electronic circuitry external to the card.
10. A card as claimed in any preceding claim wherein the card is rectangular and the electronic element is located in one corner of the card with the limb extending to the element across a major axis of the card in the region where it meets the edge of the
- 15 electronic element.
11. An electronic element comprising one or more electronic components encapsulated on a printed circuit which printed circuit has a limb portion extending from the encapsulated portion for connecting to a second part of a printed circuit of a integrated
- 20 circuit card as claimed in claim 6.
12. A card substantially as hereinbefore described with reference to Figures 2 to 11 of the accompanying drawings.

13. A method of producing an integrated circuit card comprising assembling electrical components on a limb of a printed circuit, encapsulating the components to form an electronic element and sandwiching the printed circuit and electronic element between two sheets of plastics material such that the printed circuit and electronic element become embedded in the plastics material, wherein the limb permits the electronic element to adopt its own position relative to a plane on which the printed circuit lies.

14. A method as claimed in claim 13 wherein the electronic element is fabricated on a limb of a printed circuit which limb is subsequently joined to the printed circuit.

15. A method as claimed in claim 14 wherein the electronic element is formed with tapered waist and the printed circuit with an aperture therein dimensioned such that the electronic element can be inserted through the aperture, but such that the electronic element is retained in the aperture by means of the tapered waist the electronic element substantially being connected to the printed circuit.

16. A method of fabricating an integrated circuit card as hereinbefore described with reference to Figures 2 to 11 of the accompanying drawings.

Relevant Technical Fields

- (i) UK Cl (Ed.M) B6A : AK H1R : RAS
(ii) Int Cl (Ed.5) G06K - 019/077

Search Examiner
F G Miles

Date of completion of Search
6 October 1994

Databases (see below)

- (i) UK Patent Office collections of GB, EP, WO and US patent specifications.

Documents considered relevant following a search in respect of Claims :-
1

(ii)

Categories of documents

- X:** Document indicating lack of novelty or of inventive step. **P:** Document published on or after the declared priority date but before the filing date of the present application.
Y: Document indicating lack of inventive step if combined with one or more other documents of the same category. **E:** Patent document published on or after, but with priority date earlier than, the filing date of the present application.
A: Document indicating technological background and/or state of the art. **&:** Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
Y	GB 2160366 A	(KENTON) note page 1, lines 85-9 and page 2, lines 32-6	1 at least
Y	GB 0685912 A	(STRONG) note that the "limbs" of the circuit may lie in different geometrical planes	1 at least
X	EP 0216366 A2	(CASIO) note encapsulated integrated circuits (18, 30) on one of the "limbs" of the L shaped board	1 at least
Y	US 4876441 A	(HARA) note that circuit 152 is on one "limb" of the L shaped card	